Chapter 1

Integrated Streambank Protection

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A stream's most productive and diverse habitat exists at the water's edge, where the streambank and water intersect. Here, undermined, eroded streambanks, overhanging vegetation, and fallen trees are just a few of the features that allow a diversity of fish and wildlife to find food and refuge from the main channel. The high productivity of this zone is the result of continuous change brought about by disturbance processes such as flood events. During flood events, the high energy of flowing water against the streambank causes erosion. Bank erosion, in turn, results in the introduction of trees to the river, important to the retention of gravels and refuge during high flows; gravels, present in the bank, are washed into the river and later used by salmon for spawning; and erosion introduces nutrients to the river that allows biological growth to occur. Fish and wildlife depend on these processes to provide the diversity of habitat required for their survival. This is a dynamic zone where life is both lost and regenerated. Changes in flow, within seasons and through the years, bring changes to the physical qualities of the river; and the plants and animals that depend on it adapt to and thrive with these changes.

The changing dynamics of a river can be thought of as a metaphor of the human experience. The wearing away of the old often reveals new opportunities for growth and change. Conscious (or subconscious) recognition of this, in many ways, underlies our desire to live near waterways. However, productivity of habitat is based on disturbances, such as flooding, that bring dynamic changes to the bankline. Despite their many benefits in creating productive habitat, these disturbances have also brought destruction to property and life for those living or working within a river's floodplain.

The population living within the Puget Sound basin doubled between the mid-1960s and 1999, and it is projected to reach five million by 2020 - a 78-percent increase since 1999.[1] This trend has exacerbated the conflict between allowing natural processes to occur, such as flooding and erosion, while protecting private property and infrastructure from its damaging effects. Unfortunately, both nature and people have been the losers in our efforts to resolve this conflict.

Within Washington State, between 50 and 90 percent of riparian habitat has been lost or extensively modified by human activities.[1] For instance, the lower Puyallup River, like many of our major rivers, has been so channelized, dredged and diked that it is little more than a large ditch. And, with habitat-forming processes no longer allowed to occur, fish and wildlife habitat is largely gone. While many of the major human disruptions to our river channels occurred almost a century ago, their impact continues, though on a lower scale. For instance, the practice of using rock (riprap) to stabilize eroding banks for the protection of property continues to this day. Riprap fixes the river in place, allowing no bank deformability and, therefore, limiting habitat-forming processes to occur. Riprap often leads to accelerated erosion to adjoining lands, continuing the "hardening" of a river's bankline. Natural resource impacts are primarily the result of the accumulated effects of many small bank-protection projects.

So, what can be done? Is there a way to protect people and property without destroying habitat? Yes, there often is. Indeed, the goal of the Integrated Streambank Protection Guidelines is to educate landowners, state and local governments on alternative ways to protect property and infrastructure from bank erosion while allowing for natural, habitat-forming processes to occur. Sometimes the solution will be in the design of the bank-protection project. Some habitat impacts cannot be mitigated, so sometimes the best solution will be to move infrastructure and development away from the river.

Effective, creative solutions to streambank erosion require a clear understanding of why the erosion is occurring. Integrating this information with habitat considerations, full mitigation requirements, levels and types of risk, project objectives, and design criteria is the most effective way of selecting appropriate, habitat-friendly streambank-protection treatments. These guidelines provide instruction on how to assess these key factors and how to use the results from the assessments to select appropriate streambank-protection solutions.

Prior to selecting and designing a streambank-protection project, three key factors must be considered:

1. the reason for the bank erosion;
2. the fish and wildlife habitat characteristics, needs and potential; and
3. the current and future risks associated with erosion and bank protection to property, infrastructure, fish and wildlife habitat, and public safety.

Assessing these factors from the start is crucial to achieving ecological and structural success in any streambank-protection project. In the past, fish and wildlife habitat needs were often ignored in favor of protecting other floodplain uses. Projects were designed and constructed without a full understanding of riverine and erosion processes. This often resulted in moving erosion problems downstream or upstream and failure to mitigate for the associated ecological impacts. These guidelines will help the reader to assess these factors, develop project objectives and identify design criteria. Detailed design information, for streambank-protection techniques, is also provided.

A graphic representation of the integrated streambank-protection process is shown in *Figure 1-1*.

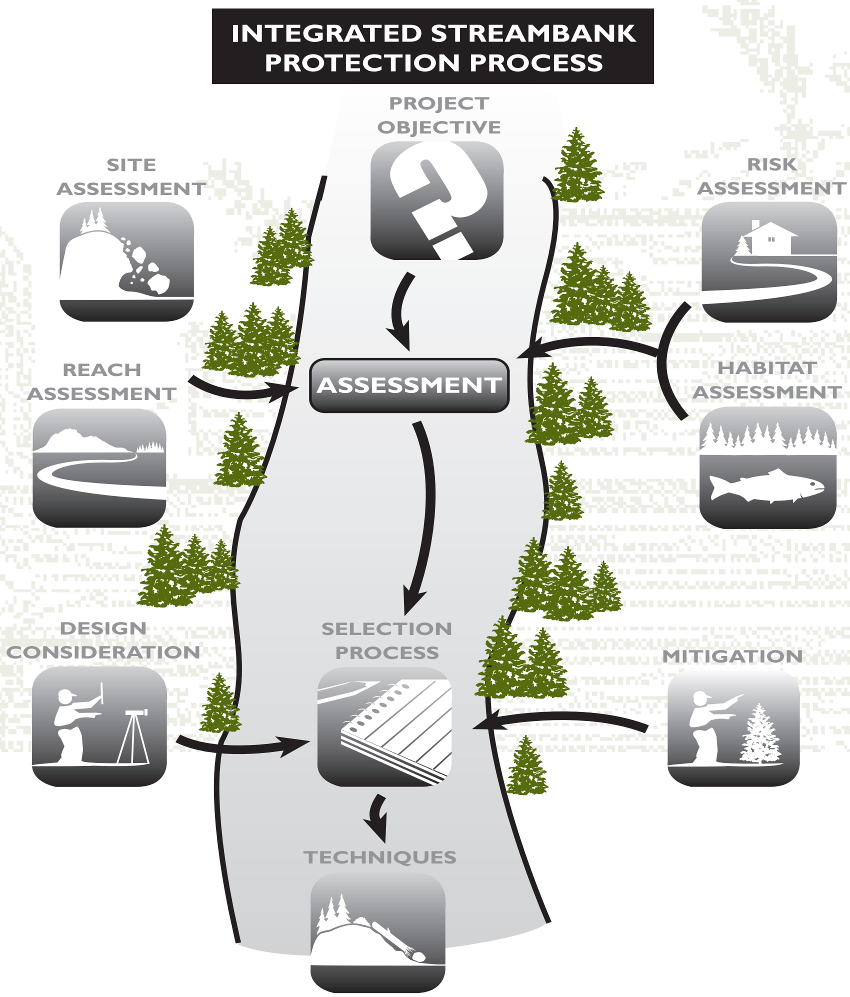

Figure 1-1. Integrated streambank-protection process.

Mitigation is a crucial component in the selection of streambank-protection treatments. Techniques must first be selected that avoid impacts to habitat. Only after exhausting the practicality of applying techniques that avoid impacts can other techniques that may impact habitat be selected. Those techniques that do have impacts must be mitigated.

These guidelines are based on ecological health and guiding principles as described in the Introduction. In 1996, J. R. Karr[2] defined ecological health as:

"An ecosystem is healthy when it performs all of its functions normally and properly; it is resilient, able to recover from many stresses, and requires minimal outside care. Ecological health describes the goal for conditions at a site that is managed or otherwise intensively used. Healthy use of a site should not degrade it for future use, or degrade areas beyond the site."

PROJECT OBJECTIVES AND DESIGN CRITERIA

Addressing a streambank-erosion problem begins with identifying the objectives of the project. The objectives of the project provide the foundation for selecting techniques and establishing design criteria. Objectives are typically stated in somewhat general or qualitative terms. For example, objectives may be stated as "preventing further erosion of the river along the highway" or "stabilizing the streambank to reduce loss of cropland." In fact, for each project there are usually a number of objectives with differing levels of priority. For example, in addition to the two objectives just identified, there may also be objectives such as "maintaining the aesthetic qualities of a streambank environment" or "maintaining or enhancing ecological values of the reach."

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Chapter 4, *Considerations for a Solution* includes a discussion of how to develop and use project objectives and design criteria in the streambank-protection selection and design process.

SITE AND REACH ASSESSMENT

Identifying suitable streambank-protection alternatives begins with an understanding of the specific "mechanisms" and "causes" of erosion. Correctly identifying the mechanisms and causes of erosion is critical to selecting appropriate bank protection solutions.

The "mechanism of failure" is the physical action, or process, within the bank that results in bank erosion. There are five mechanisms of failure:

1. toe erosion,
2. scour,
3. mass failure,
4. subsurface entrainment, and
5. avulsion and chute-cutoff potential.

The "cause of erosion" is what activates the mechanism of failure. There are two types of causes:

1. site-based (such as elimination of vegetation at the site), and
2. reach-based (such as a stream that has been confined by dikes).

Identifying suitable streambank-protection alternatives begins with an understanding of the specific "mechanisms" and "causes" of erosion.

Although often difficult to identify, the single cause or combined causes of erosion, can be determined with careful evaluation. Often, reach-based causes generate site-based causes. The mechanisms and causes of erosion may be natural or triggered by human activities. The mechanisms of failure and site-based causes of erosion are described in Chapter 2, *Site Assessment*. Reach-based causes of erosion are described in Chapter 3, *Reach Assessment*.

Site and reach assessments should identify existing habitat conditions and the habitat potential. During site and reach assessments, it is important to recognize that streambank erosion is a natural process essential to habitat function and its creation. For example, an over-hanging streambank with exposed plant roots provides cover habitat. Habitat creation (or, conversely, damage to habitat) resulting from streambank erosion is a critical component of site and reach assessments.

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HABITAT CONSIDERATIONS AND MITIGATION

The first priority of natural resource agencies in reviewing a streambank project is to avoid habitat impacts. If damage to habitat cannot be avoided, then mitigation is required. Direct impacts can be mitigated by restoring the damaged or lost ecological functions of the stream. Indirect impacts, such as the future loss of valuable side-channel habitat, sources of salmon spawning gravel and large woody debris, arise from streambank-hardening practices, which prevent the channel from migrating laterally.[3] A streambank-protection project situated on a previously undisturbed river reach can be problematic, because it can easily cause the need for more streambank-protection projects elsewhere along the river, increasing the chances of further damage to habitat. By recognizing the long- and short-term effects of indirect impacts to the reach, mitigation can be incorporated into the design of the project, either on-site or off-site.

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Chapter 4 provides an explanation of various habitat characteristics and how they might be affected by streambank-protection projects. Mitigation, as it relates to streambank-protection projects, is also described. The determination of habitat-mitigation requirements may vary among projects depending upon regulatory jurisdiction of a site and whether species listed under the Endangered Species Act might be affected. The tools provided here are, therefore, general and are intended to assist the designer regardless of the policy and actual mitigation requirement applied. These guidelines support and provide technical guidance for existing regulations and policies in Washington State. While the guidelines help to identify the most appropriate design, it's important to remember that, even with the best science and best project and mitigation design, a project may have habitat impacts that cannot be mitigated.

RISK ASSESSMENT

All streambank-protection projects contain some level of risk. For example, a streambank-protection project may be effective at lower flows, but may fail as a result of a larger flood. Likewise, fish-cover habitat along an undercut, vegetated streambank may be at risk by the placement of certain streambank-protection techniques.[4]

Throughout the design process, it is important to understand and evaluate the many types and levels of risk associated with a streambank-protection project. A risk assessment considers both the risks associated with continued streambank erosion and those of the proposed project with respect to property, habitat and public safety. A more detailed discussion of risk can be found in Chapter 4.

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SELECTION PROCESS

One of the most important aspects of the design process is moving from the site and reach assessments to the selection of an appropriate solution. Selecting appropriate streambank treatments involves integrating the site and reach assessments, project objectives, risk, habitat considerations, mitigation, and design considerations. The selection process is described in Chapter 5, *Identify and Select Solutions*.

The three screening matrices provided in Chapter 5 will assist the reader in selecting streambank-protection treatments that:

- perform adequately to meet streambank-protection objectives;
- are appropriate with respect to mechanisms of failure and site- and reach-based causes;
- are considered with an understanding of the potential impacts to habitat caused by each technique; and
- are selected in order of priority to first avoid, second minimize, and third compensate for habitat impacts.

These matrices screen treatments based on:

- site conditions,
- reach conditions, and
- habitat impacts.

Within each matrix, streambank-protection techniques and their applicability are listed, assisting the reader to accept or reject a particular technique. With each subsequent matrix, inappropriate techniques are progressively screened out, leaving a suite of feasible techniques. Throughout the process of identifying an appropriate streambank-protection technique, the question should always be posed whether the best course of action might be taking no action at all.

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STREAMBANK-PROTECTION TECHNIQUES

These guidelines provide information about streambank-protection techniques applicable within the state of Washington (*see Table 1-1*). In addition to the streambank-protection techniques, several mitigation techniques are also provided. For each technique, the following information is provided:

- description of the technique;
- typical application, variations, emergency, site and reach limitations;
- effects on geomorphology, habitat and hydraulics;
- design criteria and considerations;
- biological considerations, such as mitigation requirements for the technique or mitigation benefits provided by the technique;

The question should always be posed whether the best course of action might be taking no action at all.

Flow-Redirection Techniques	Structural Bank-Protection Techniques	Biotechnical Bank-Protection Techniques	Internal Bank-Drainage Techniques	Avulsion-Prevention Techniques	Other Techniques
Groins Buried groins Barbs Engineered log jams Drop structures Porous weirs	Anchor points Roughness trees Riprap Log toes Rock toes Cribwalls Manufactured-retention systems	Woody plantings Herbaceous cover Soil reinforcement Coir logs Bank reshaping	Subsurface drainage systems	Floodplain roughness Floodplain grade control Floodplain flow spreader	Channel modification Riparian-buffer management Spawning-habitat restoration Off-channel spawning and rearing habitat No action

Table 1-1. List of streambank protection techniques organized by functional group.

- risk (to habitat and adjacent properties, and level of reliability of the technique);
- construction considerations, such as materials required, timing considerations, cost;
- maintenance needs;
- monitoring considerations;
- examples, such as typical drawings, site examples and photographs; and
- references.

CONCLUSION

There are times when streambank protection is necessary to provide public safety, correct or prevent damage to property, or even to create fish and wildlife habitat. However, the impacts of such protection can have enormous consequence to the health and stability of the stream. The goal of the Integrated Streambank Protection Guidelines is to assist individuals, organizations, and state and local governments with addressing streambank-erosion concerns through an informed decision-making process, and protecting the public and property while avoiding or minimizing damage to fish and wildlife habitat.

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